Arm and Leg Coordination during Gait in Children with Cerebral Palsy and Typically Developing Children

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Introduction

Arm swing movements are important in human locomotion[1]. Normal arm swing appears to require little effort but is an integral part of the energy economy of human gait [2]. Unfortunately, little is known about the coordination of arm and leg movements during gait in children with Cerebral Palsy (CP). Therefore, in the present study step length and arm swing length during gait was compared between children with CP and typically developing (TD) children. In addition, we studied the effect of walking speed on these variables.

Clinical Significance

Treadmill training is increasingly used in the rehabilitation of gait in children with CP. Some types of training do not allow arm movements and one may wonder whether this is an appropriate strategy. To answer this type of question it is essential to know the role of arm movements during gait in children with CP as compared to TD children.

Methods

A total of 26 children with CP (4-12 yr) and 24 TD children (5-12 yr) were included. The CP group included 11 children with hemiplegia and 15 with diplegia, based on the following criteria: ambulant (no walking aids), predominantly spastic type of CP, no Botox A treatment within the past 6 months, no orthopedic surgery and no ataxia. Total body kinematics were recorded using an 8 camera Vicon system with the Plug-in-Gait model. Three trials were assessed for each condition (preferred speed & as fast as possible). To calculate arm swing length, first the finger marker was projected on the sagittal plane. Arm swing length was then determined as the difference of maximum and minimum displacement of the finger marker along the x-axis (corrected for forward motion). Step length was determined as the distance between contralateral toe to ipsilateral toe along the x-axis. To take into account size differences between children, step length and arm swing were normalized by dividing them by the subjects height. The asymmetry index (AI) was calculated as follows: $(X_{affected}-X_{unaffected})/(max_X)*100$. Within subject variability was expressed as coefficient of variation (CV). To compare the different groups for the step length, arm swing length AI and CV, we used a two-way repeated measures analysis of variance (speed always as a factor) and post hoc Tukey's test. First the CP group was compared to the TD children, then children with hemiplegia were compared with the children with diplegia.

Results

The three groups (hemiplegia, diplegia, TD) were not significantly different for age ($p=0.07$) and weight ($p=0.09$), but were different for height ($p=0.03$). They did not differ significantly when divided into two groups: CP and TD (age: $p=0.7$; weight: $p=0.2$; height: $p=0.05$).
In general, we found that the step length was decreased in CP versus TD ($p<0.01$) whereas the length of arm swing was similar in both groups ($p=0.15$) (see Fig. 1). Comparing the two CP groups, children with hemiplegia (mean±SD) (0.43±0.04) had significantly increased step length compared to children with diplegia (0.36±0.07) ($p<0.01$). The length of arm swing did not differ between the two groups ($p=0.5$). Children with hemiplegia had significant increased arm swing length on the unaffected side (0.26±0.11) than on the affected side (0.13±0.07) ($p<0.01$).

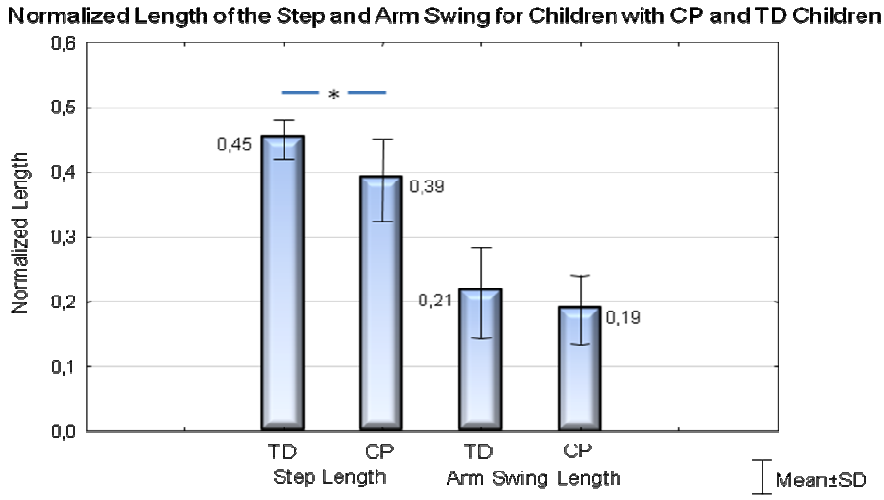

Fig. 1. Mean values and standard deviations of the normalized step length and arm swing length for children with CP and TD children (averaged for the two conditions) (*:p<0.01)

No significant differences were found in the asymmetry index of the step length (p=0.29) and arm swing length (p=0.17) between children with CP and TD children. Children with diplegia did not show a significant different AI in step length compared to children with hemiplegia (p = 0.11). However, children with hemiplegia (-41.5±38.28) had significantly increased asymmetry in arm swing length than children with diplegia (-7.02±34.77) (p=0.01).
Children with CP had more variable step length (0.07±0.05) (p=0.02) and arm swing length (0.3±0.2) (p=0.01) than TD children (step:0.05±0.03; arm:0.23±0.14). However, no differences in variability of step length (p=0.2) and arm swing length (p=0.9) were found between the children with hemiplegia and diplegia.
In both children with hemiplegia and diplegia, and in TD children the speed had a significant effect on the step length (p<0.01). For arm swing length, however, speed did not have an effect in the children with CP (hemiplegia: p=0.87; diplegia: p=0.08) while it did have an effect in the TD children (p<0.01). Speed did not significantly influence the CV nor the AI of these measures.

Discussion

Children with CP have smaller step length than TD children whereas their arm swing amplitude is comparable. However, children with CP were found to have more variable step and arm swing length than TD children. Children with hemiplegia have a more asymmetric arm swing length than children with diplegia. The arm swing length on the unaffected side is increased compared to the affected side in children with hemiplegia. Both CP populations are equally variable in their step length and arm swing amplitude. Speed did not influence variability nor asymmetry. More research is needed to further investigate the role of arm movements during gait in children with CP. Mainly mildly affected children with CP (GMFCS I) were included in the current study. Broadening the scope to more severely affected children could yield interesting results.

Reference List

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